

REPORT DOCUMENTATION PAGE

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| 6. AUTHOR(S) Steven M. Buc | | | | | |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) SAA International, Ltd. 53 Lake Park Court Germantown, Maryland 20874 | | | | 8. PERFORMING ORGANIZATION REPORT NUMBER 97-07 | |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Crane Division, Naval Surface Warfare Center Crance, IN 47522-5001 ATTN: Code 4033, Mr. Don Rumble | | | | 10. SPONSORING/MONITORING AGENCY REPORT NUMBER | |
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| 12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited | | | | 12b. DISTRIBUTION CODE DTIC QUALITY INSPECTED 2 | |
| 13. ABSTRACT (Maximum 200 words) The primary emphasis of this study was to develop less expensive alternative grenade attachment concepts, which offer better fabrication and performance reliability than the current rope and band assembly. To this end, this study comprised four inter-related tasks: alternative attachment concept development, computer modeling dynamic structural analysis, prototype fabrication and testing, and manufacturing process development and cost analysis. Early in the project, after detailed review of the entire TDP, we began to suspect that the grenade attachment scheme may be only one of several significant system cost drivers. For this reason, the system cost analysis was expanded early to include a detailed assessment of other component and subassembly costs. This approach permitted the alternative grenade attachment concepts developed in this study to be evaluated with respect to other significant cost reducing and reliability enhancing modifications. | | | | | |
| 14. SUBJECT TERMS computer flyout simulation explosive line charge, rocket motor, manufacturing cost, process improvement, materials, assemblies | | | | 15. NUMBER OF PAGES 29 | |
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8 July 1997

Contract Summary

MANUFACTURING TECHNOLOGY FOR THE APOBS SYSTEM

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PROGRAM OBJECTIVES

- ▲ Utilize existing models to determine viability of baseline APOBS configuration.
- ▲ Develop alternatives, paying particular attention to attachment techniques.
- ▲ Perform dynamic structural analyses
- ▲ Prototype and test potential alternative attachments
- ▲ Perform manufacturing and cost analyses.

TASK STRUCTURE SUMMARY

- Task 1 - Develop alternative attachment schemes that will support improved performance and reliability, yet result in reduced assembly time and reduced cost.
- Task 2 - Perform a dynamic structural analysis of the APOBS system in order to better understand design loads and related safety factors.
- Task 3 - Prototype and test a family of alternative configurations in order to demonstrate their viability and to validate the modeling that has been performed.
- Task 4 - Perform a manufacturing and cost analysis in order identify the cost drivers and to demonstrate the economy and efficiency of the design.

HOW DID WE DO THIS?

- ▶ We utilized our in-house line throwing simulation (FLYOUT) to determine the stresses on the grenades as the APOBS is launched and flies out.
- ▶ We compared the simulation results with actual experience in the prior APOBS tests.
- ▶ We performed static tests to determine the effects of the calculated stresses on the attachments.
- ▶ We identified the critical attachment parameters and methodically corrected perceived deficiencies.
- ▶ We constructed dummy line charge segments and made a series of launches using our internal gun test facility.

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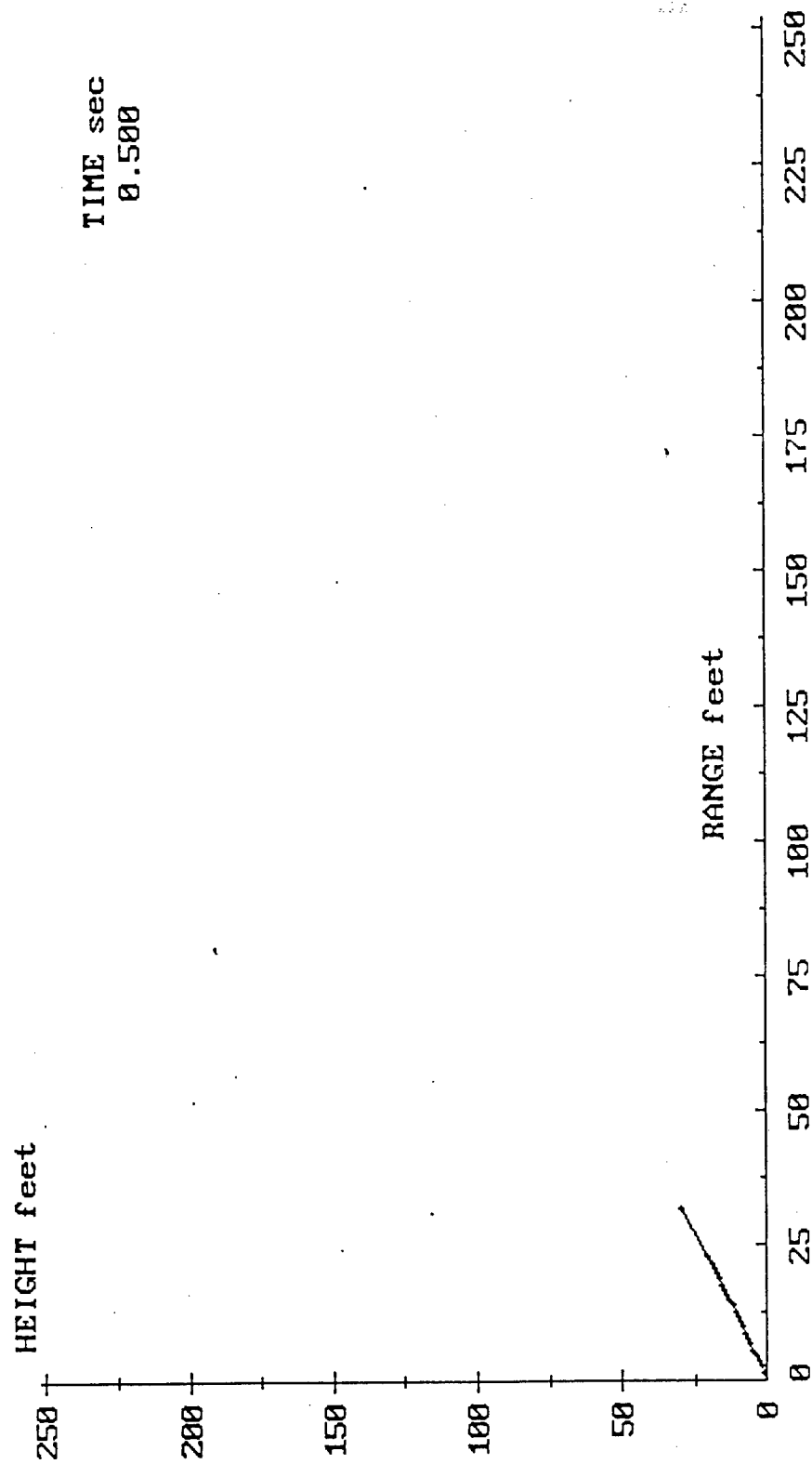


Figure 2 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 0.500 SECONDS.

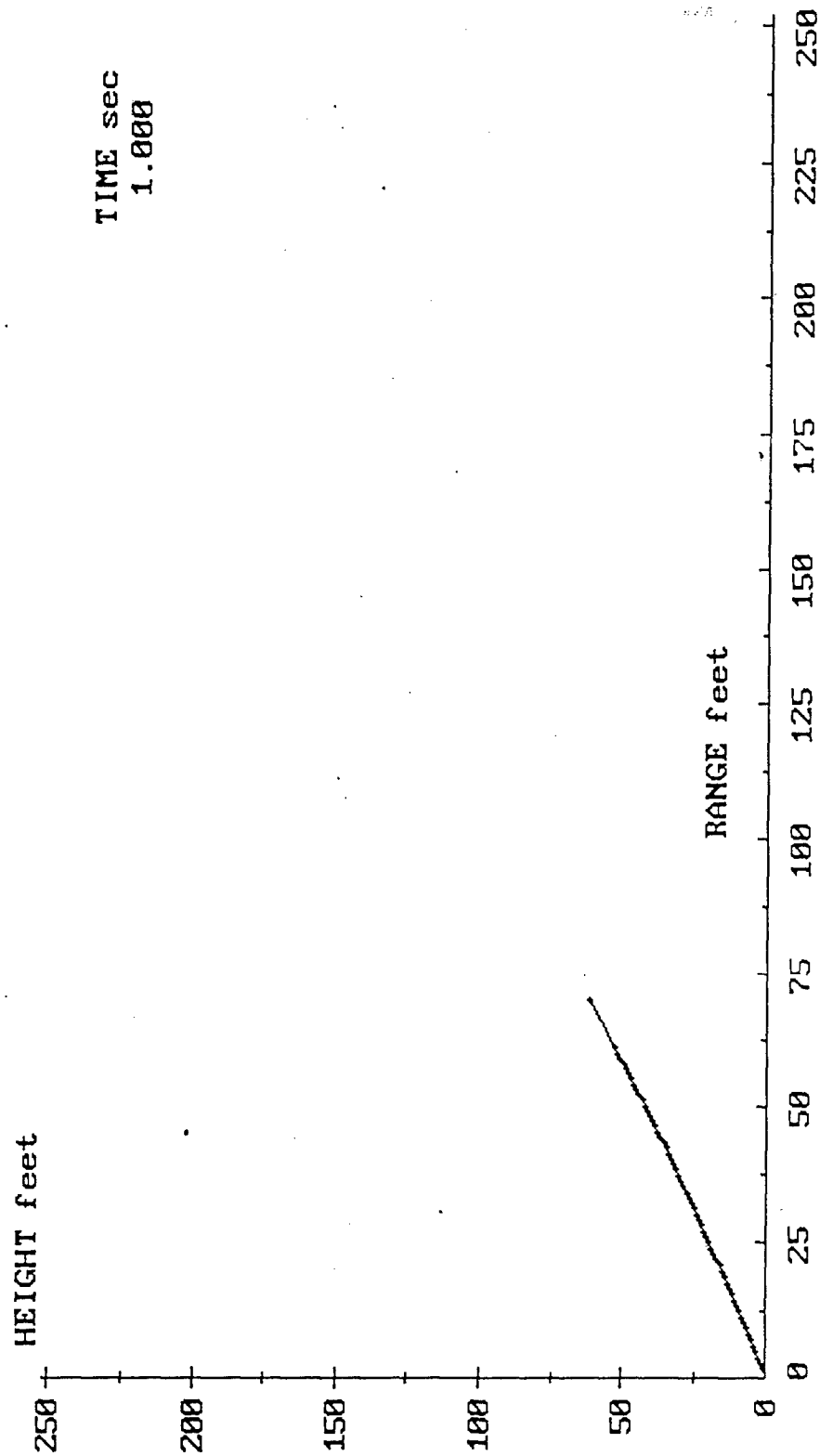


Figure 3 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 1.000 SECONDS.

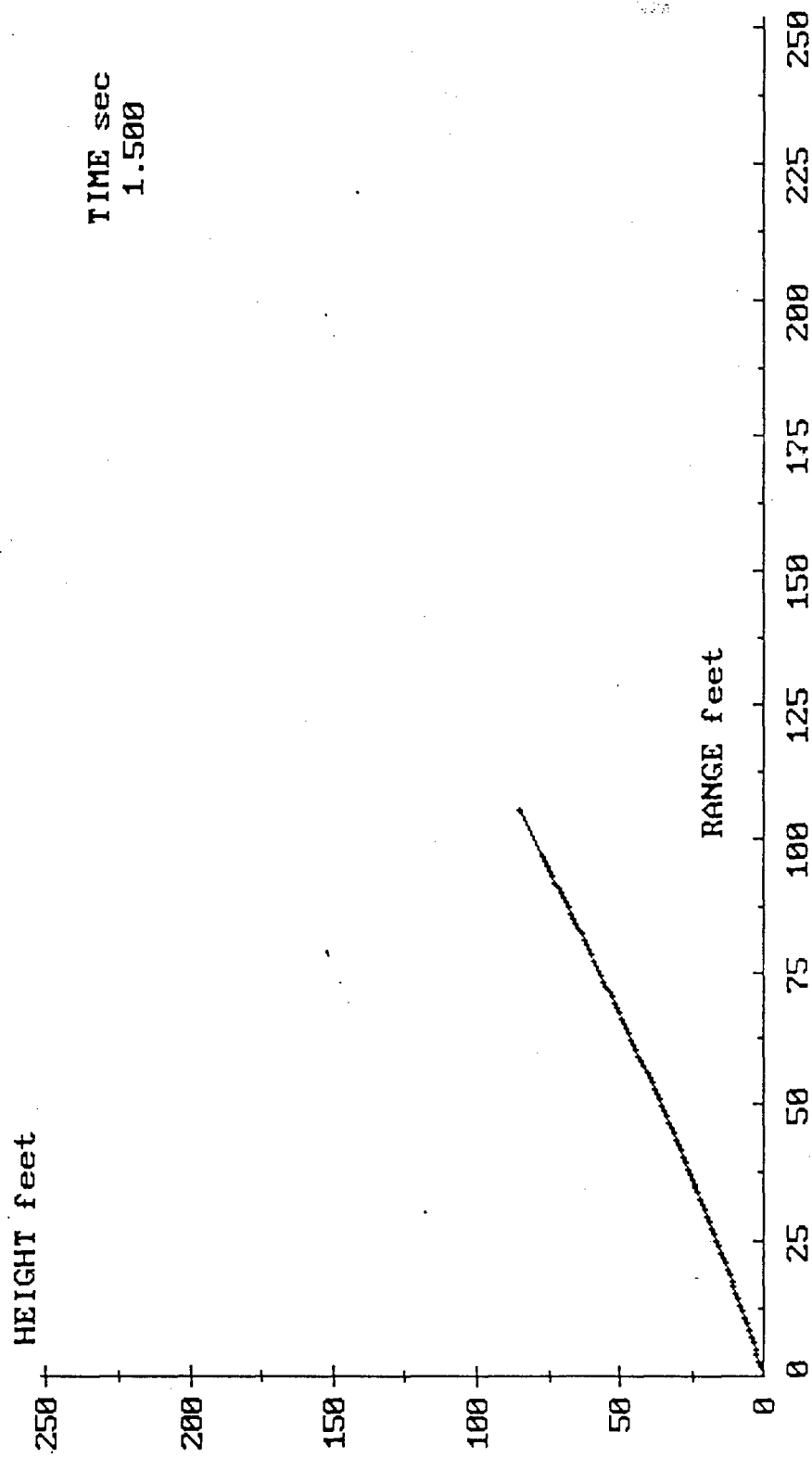


Figure 4 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 1.500 SECONDS.

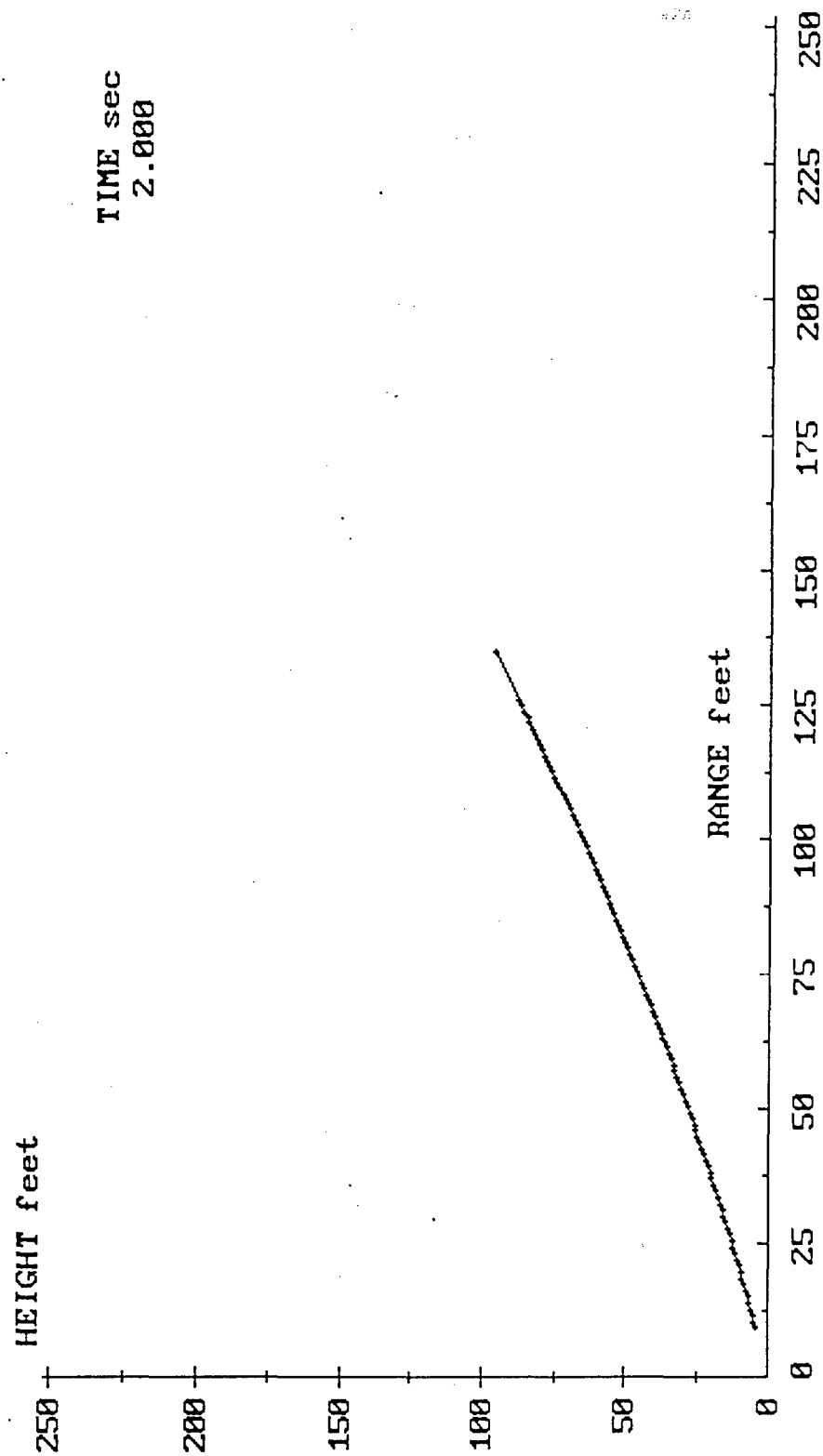


Figure 5 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 2.000 SECONDS.

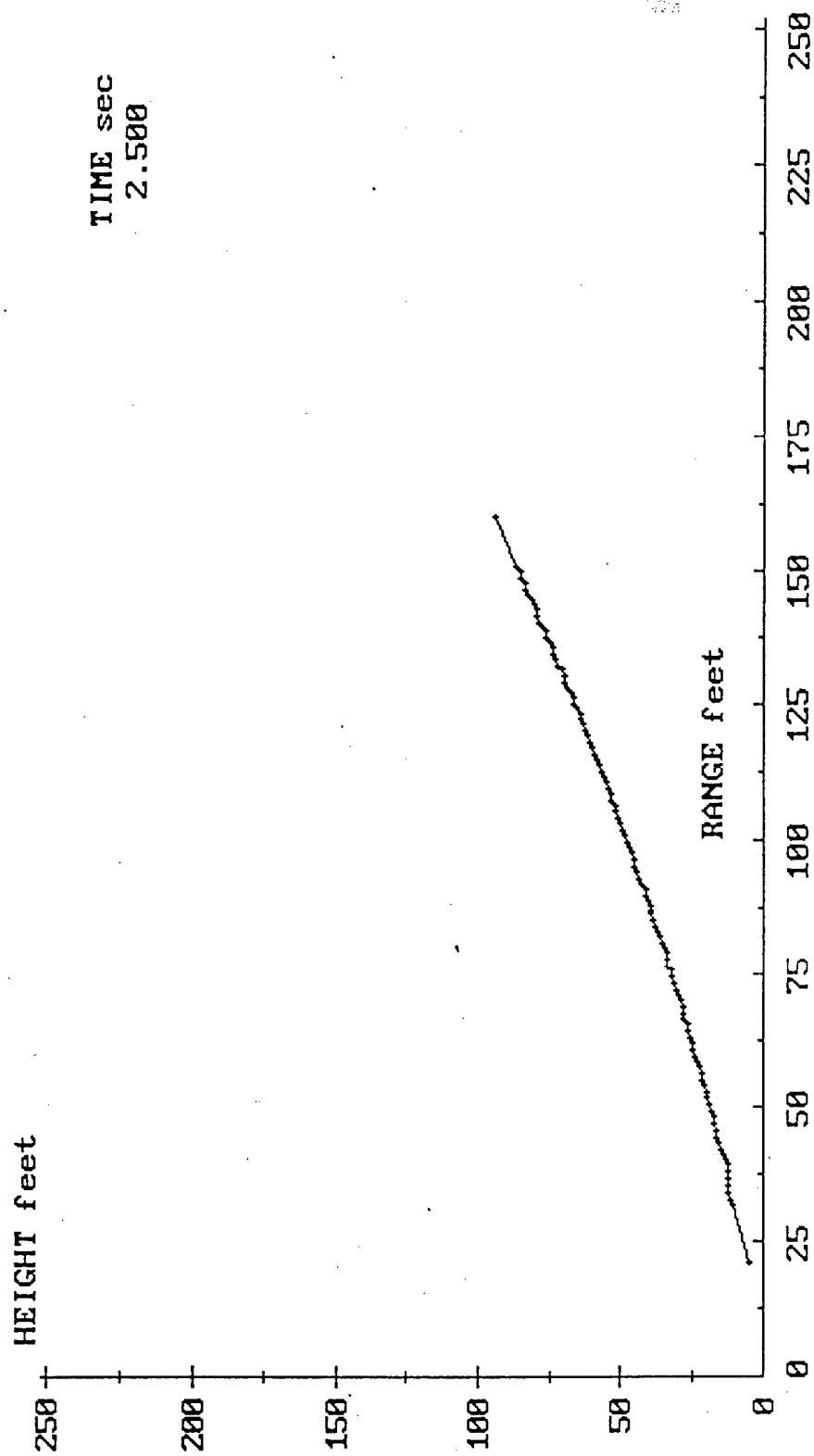


Figure 6 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 2.500 SECONDS.

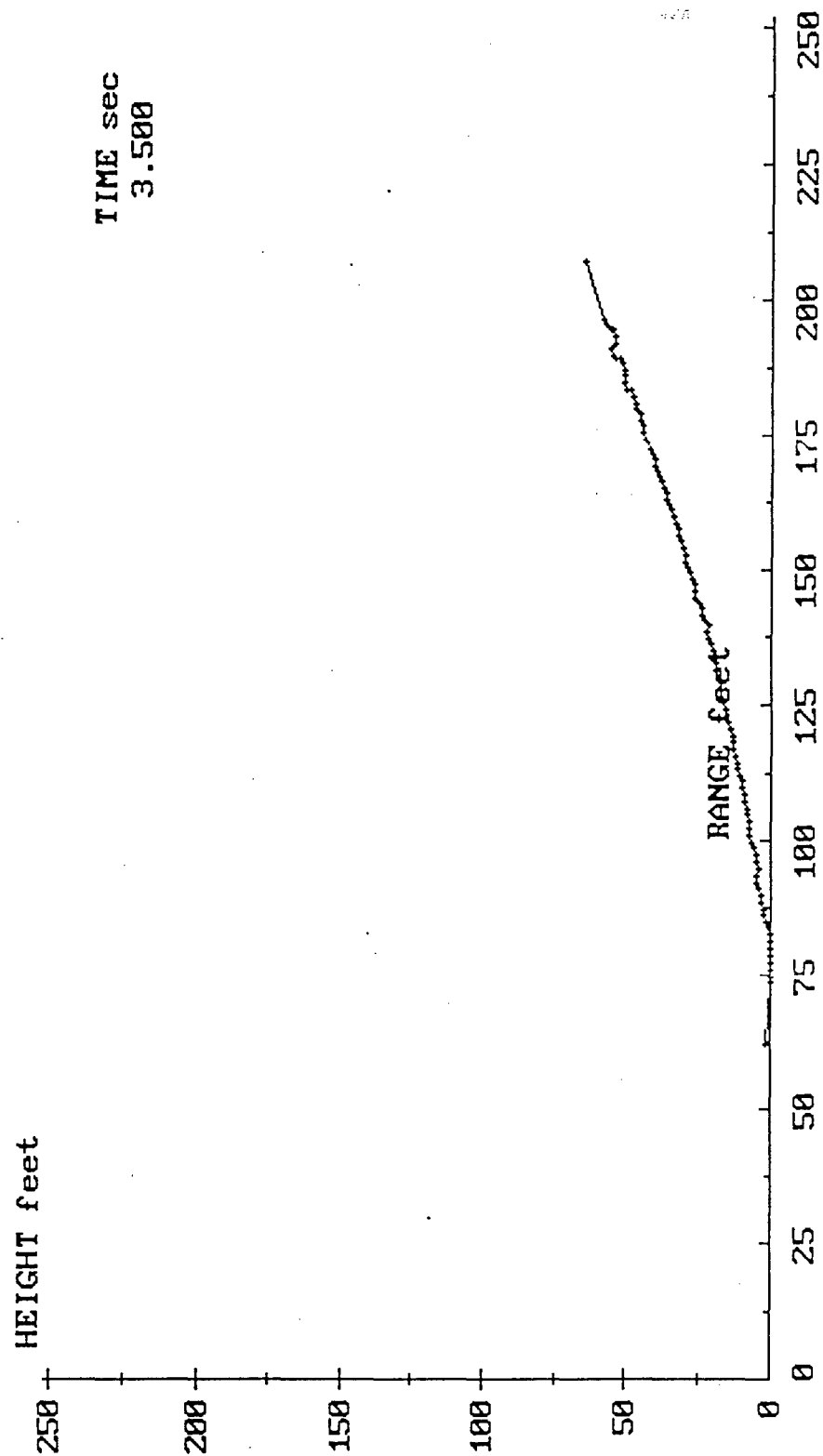


Figure 7 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 3.500 SECONDS.

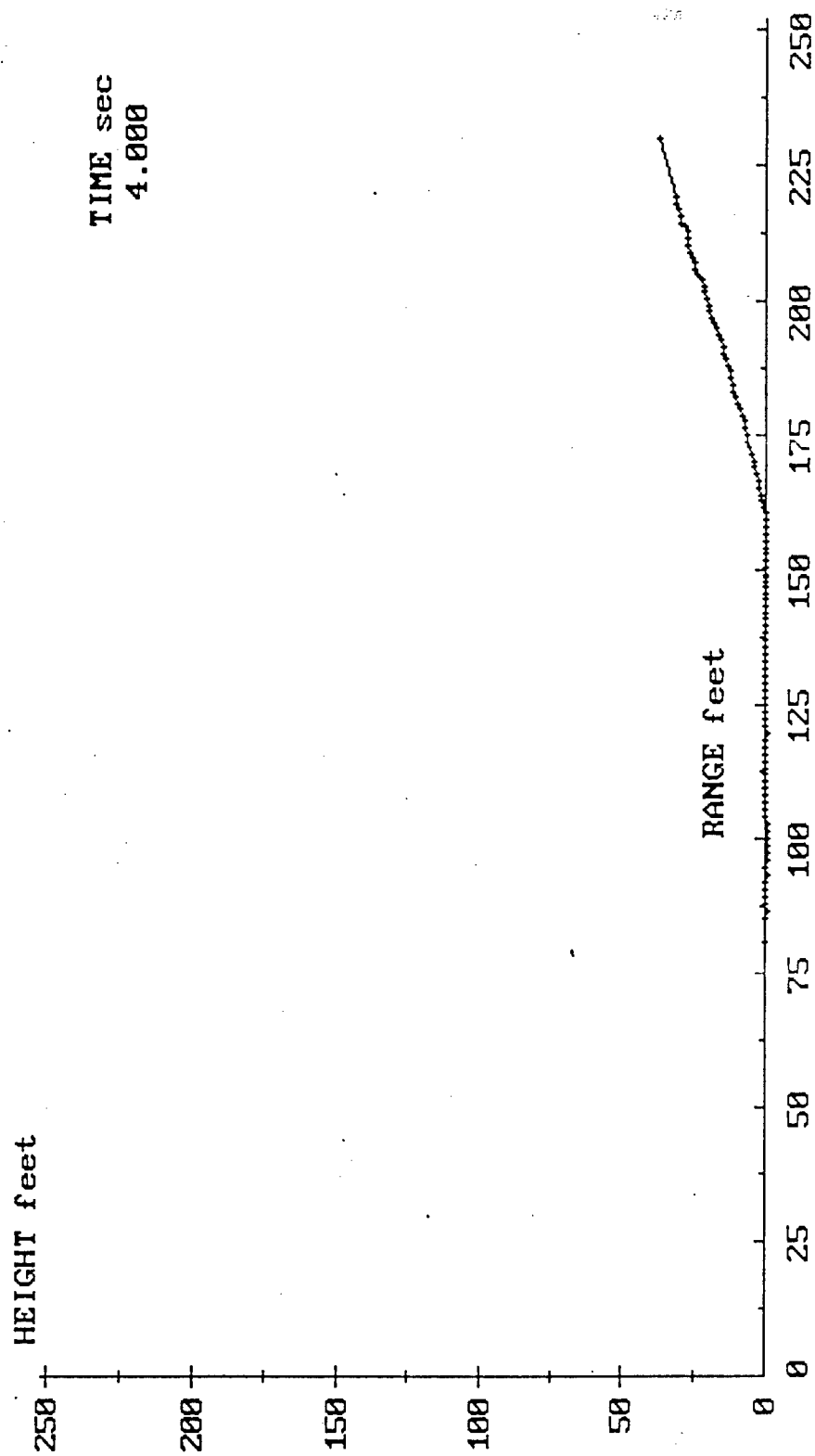


Figure 8 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 4.000 SECONDS.

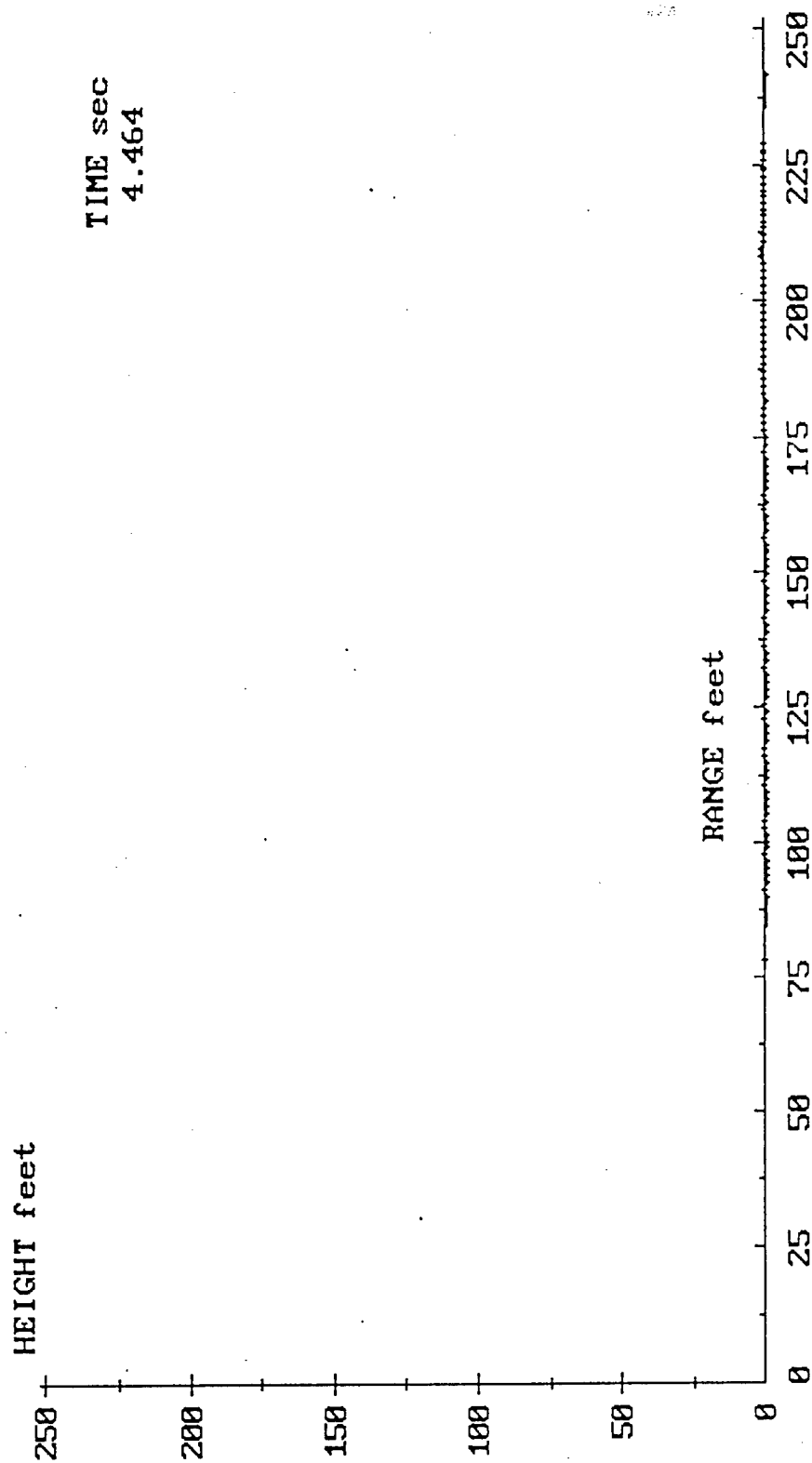
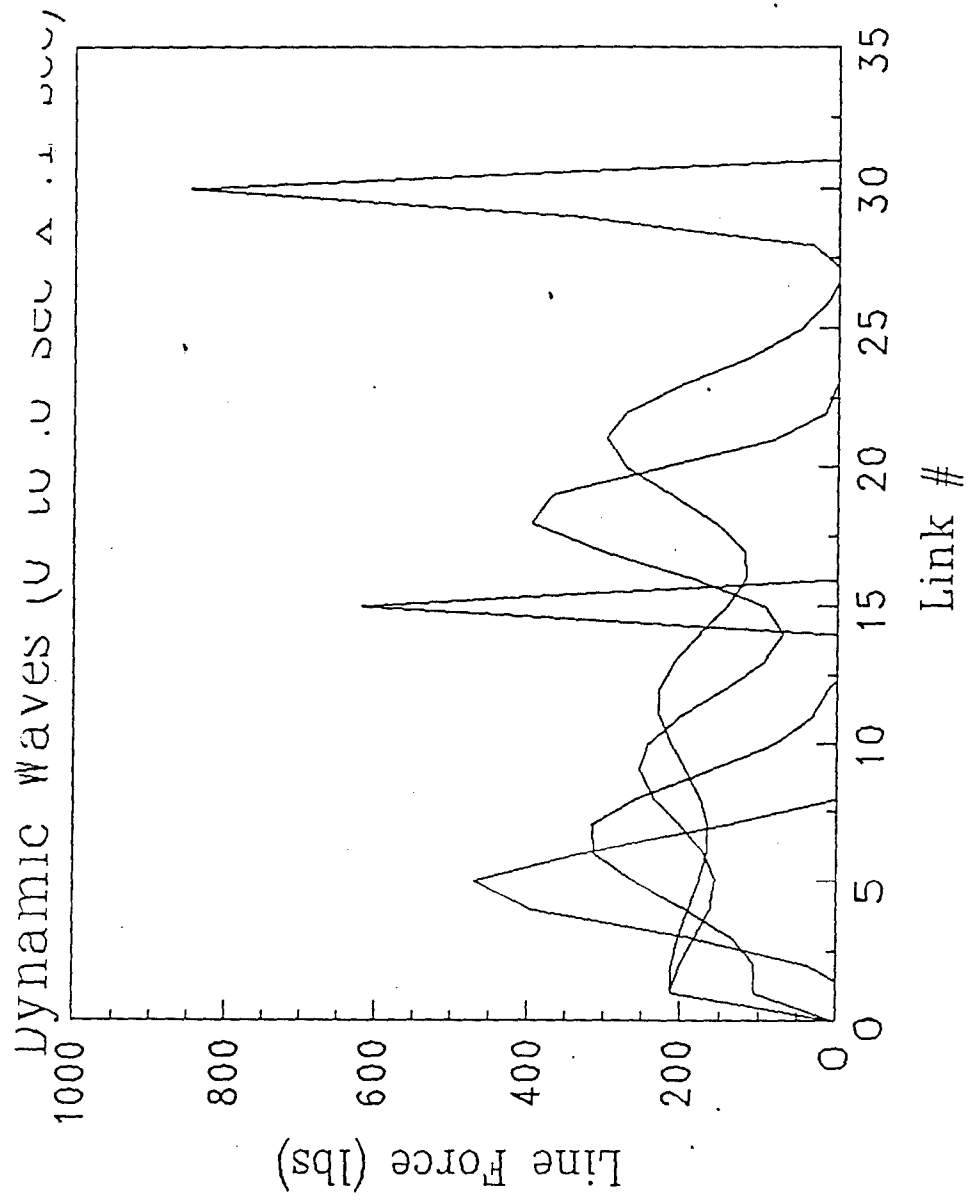


Figure 9 - ELAPSED TIME PLOT SHOWING THE POSITION OF THE APOBS LINE CHARGE
AT 4.464 SECONDS.



DESIGN PERFORMANCE

| LINK # | DESCRIPTION | F_{MAX} (lb) | F_{DESIGN} (lb) |
|----------|-----------------------------|----------------|-------------------|
| 1 | MOTOR BRIDLE | 473 | 900 (SPEC) |
| 2 | FUZE TO FIRST GRENADE | 1141 | 1187 (SPRING) |
| 3 - 61 | ALL OTHERS - FRONT ASSEMBLY | 735 TO 897 | 3200 (1/4" rope) |
| 62 | 60th GRENADE TO CONNECTOR | 960 | 3200 (1/4" ROPE) |
| 63 | CONNECTOR TO 61st GRENADE | 1026 | 1187 (SPRING) |
| 64 - 111 | ALL OTHERS REAR ASSEMBLY | 421 - 818 | 3200 (1/4" rope) |
| 112 | PARACHUTE BRIDLE | 306 | 600 (SPEC) |

SOME INTERESTING OBSERVATIONS

- ▶ All of the connections experience greater tensile forces than the rocket motor thrust of 200 pounds.
- ▶ The flyout is not a static process.
- ▶ The rocket motor accelerates and reaches a high velocity before the slack is taken up.
- ▶ Elastic tensile waves are developed, and they travel up and down the line, making a quantitative understanding of the flyout dynamics impossible without a validated simulation tool.
- ▶ The superposition of these waves, which travel faster than the line charge, causes brief duration, extremely high stresses in some of the links.
- ▶ The magnitude of these forces is sufficient to risk a failure.
- ▶ The waves are damped by the energy absorption, primarily elastic deformation, of the rope as it stretches.
- ▶ The knowledge of elastic characteristics of the rope and the connections are critical.

S A A

FLYOUT PERMITTED US TO INVESTIGATE WAYS TO REDUCE THE ELASTIC WAVE EFFECTS

- ▶ We can shorten the motor bridle so that the rocket does not have as much speed when it grabs the fuze.
- ▶ This results in a smaller amplitude stress wave.
- ▶ Rope elasticity can be modified to reduce stress wave peaks.

DESIGN PERFORMANCE WITH SHORTER BRIDLES

DESIGN PERFORMANCE WITH 48 INCH MOTOR BRIDLE

| LINK # | DESCRIPTION | F _{MAX} (lb) | 144" BRIDLE (lb) |
|----------|-----------------------------|-----------------------|------------------|
| 1 | MOTOR BRIDLE | 291 | 473 |
| 2 | FUZE TO FIRST GRENADE | 786 | 1141 |
| 3 - 61 | ALL OTHERS - FRONT ASSEMBLY | 568 - 818 | 735 - 897 |
| 62 | 60th GRENADE TO CONNECTOR | 851 | 960 |
| 63 | CONNECTOR TO 61th GRENADE | 976 | 1026 |
| 64 - 111 | ALL OTHERS - REAR ASSEMBLY | 410 - 791 | 421 - 818 |
| 112 | PARACHUTE BRIDLE | 341 | 306 |

DESIGN PERFORMANCE WITH 24 INCH MOTOR BRIDLE

| LINK # | DESCRIPTION | F _{MAX} (lb) | 144" BRIDLE (lb) |
|----------|-----------------------------|-----------------------|------------------|
| 1 | MOTOR BRIDLE | 222 | 473 |
| 2 | FUZE TO FIRST GRENADE | 629 | 1141 |
| 3 - 61 | ALL OTHERS - FRONT ASSEMBLY | 502 - 812 | 735 - 897 |
| 62 | 60th GRENADE TO CONNECTOR | 889 | 960 |
| 63 | CONNECTOR TO 61th GRENADE | 1022 | 1026 |
| 64 - 111 | ALL OTHERS - REAR ASSEMBLY | 412 - 777 | 421 - 818 |
| 112 | PARACHUTE BRIDLE | 213 | 306 |

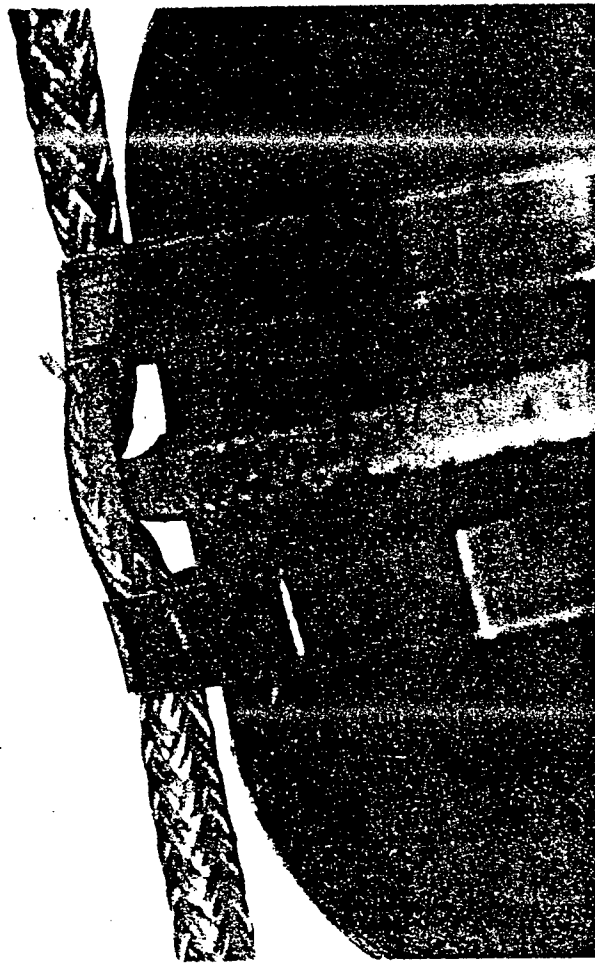
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EFFECTS OF REDUCED STIFFNESS

- ▶ Much can be gained by modifying both bridle length and line charge stiffness.
- ▶ Adequate design safety factors can be achieved with zero weight penalty.

STATIC TEST RESULTS

- ▶ Calibrated pull force of 200 pounds was applied to existing attaching bands.



POTENTIAL ALTERNATIVE ATTACHMENT TECHNIQUES

S A A

A high-contrast, black and white photograph of a rope with a distinct woven texture. The rope is arranged in a large, roughly rectangular shape, with two loops formed in the lower half. The loops are positioned on the left and right sides, facing each other. The background is dark and grainy, with some lighter, horizontal streaks. The overall image has a high level of contrast, with the rope appearing as a bright, textured line against the dark background.

Figure 17 - Illustration of Loop Knots

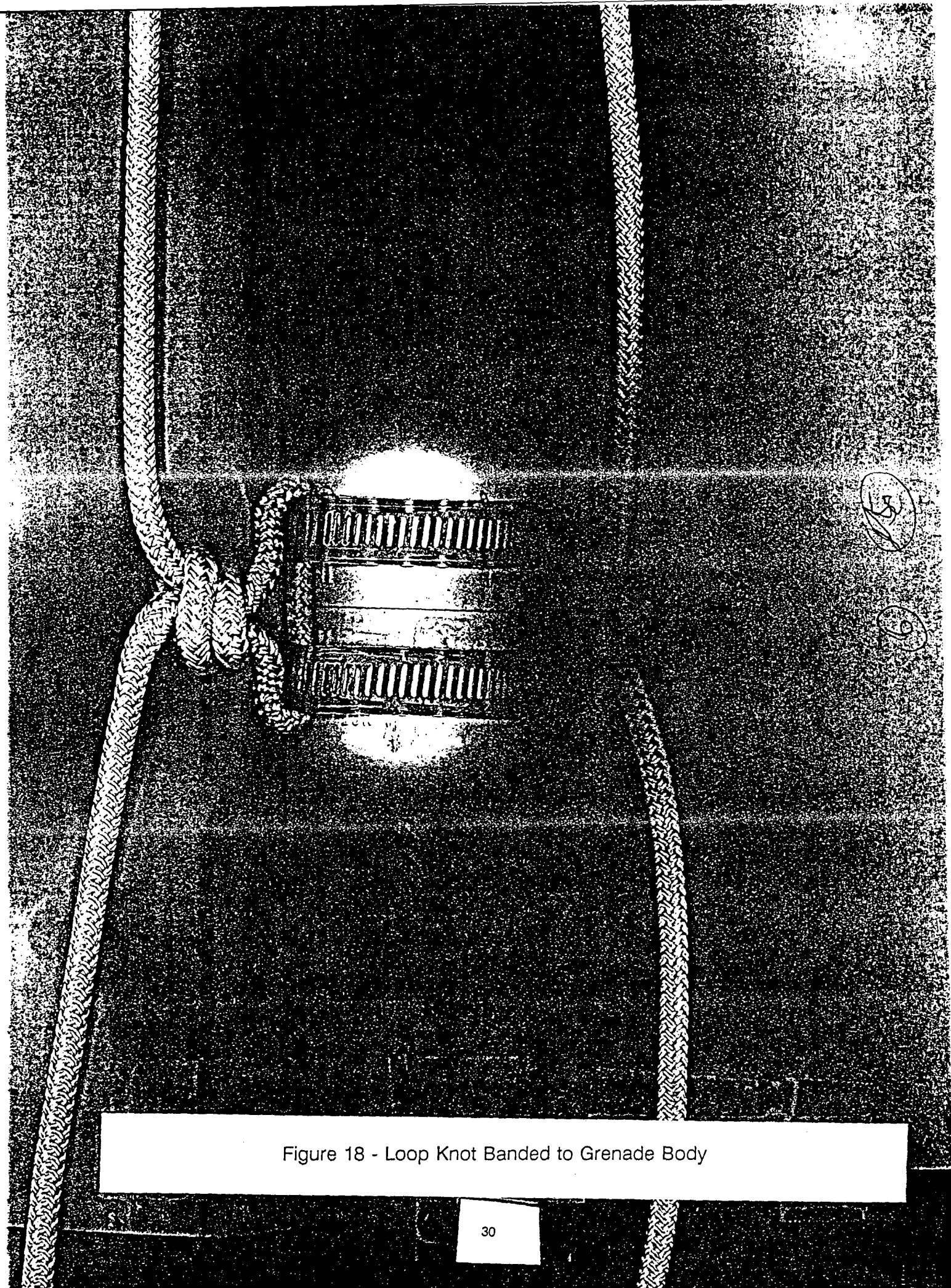


Figure 18 - Loop Knot Banded to Grenade Body

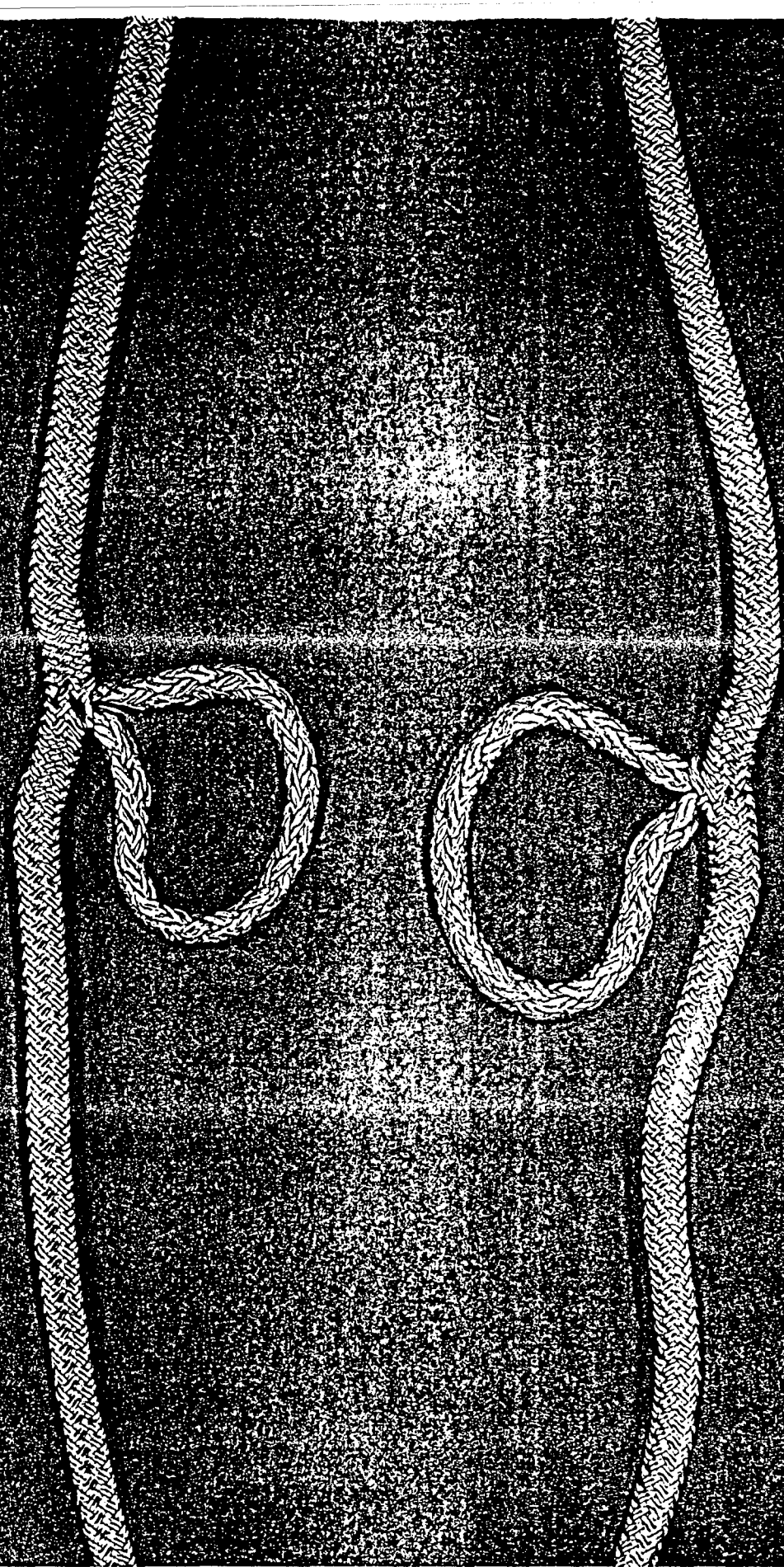


Figure 19 - Modification of Banding Technique Using Inner Core of Line

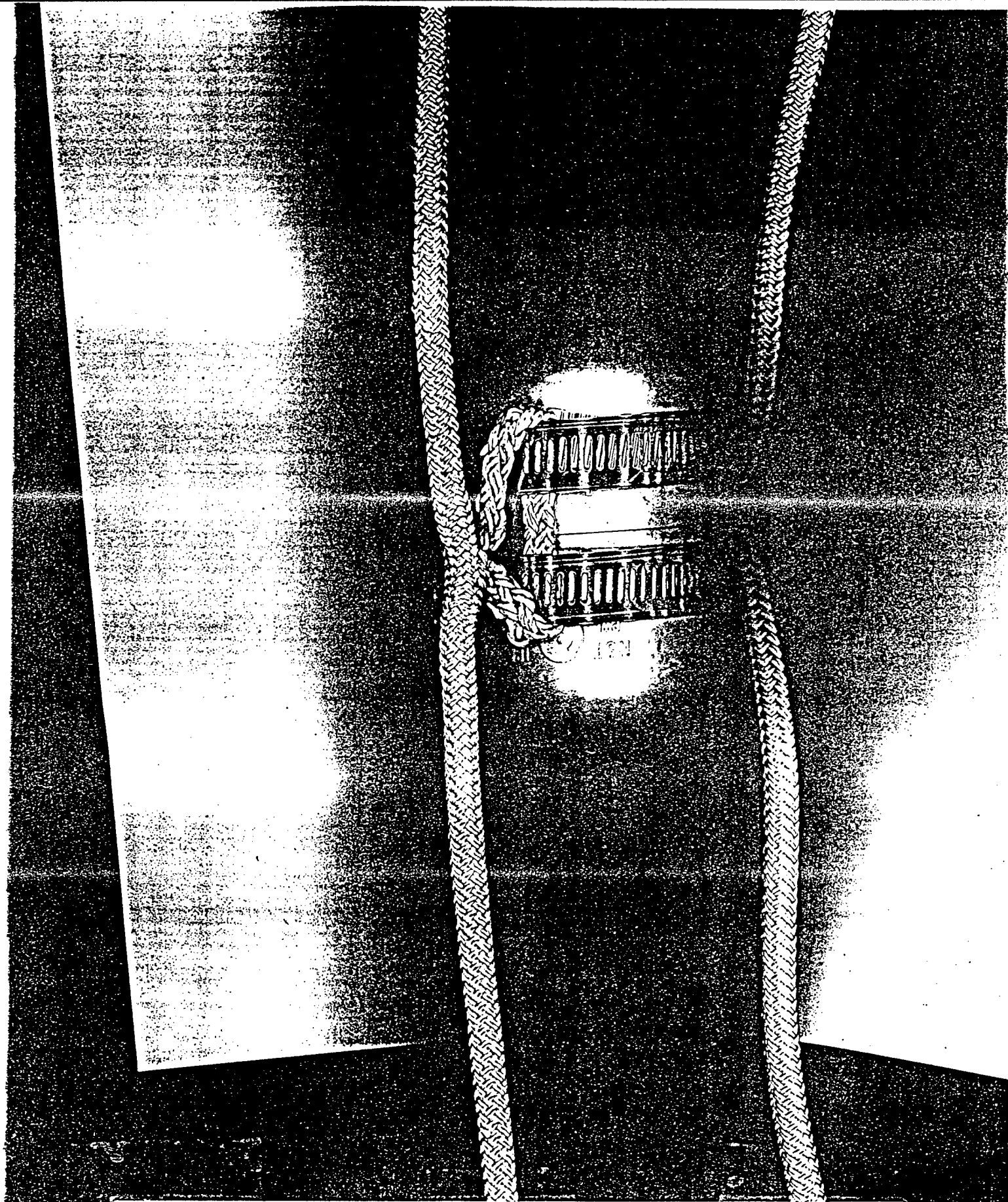
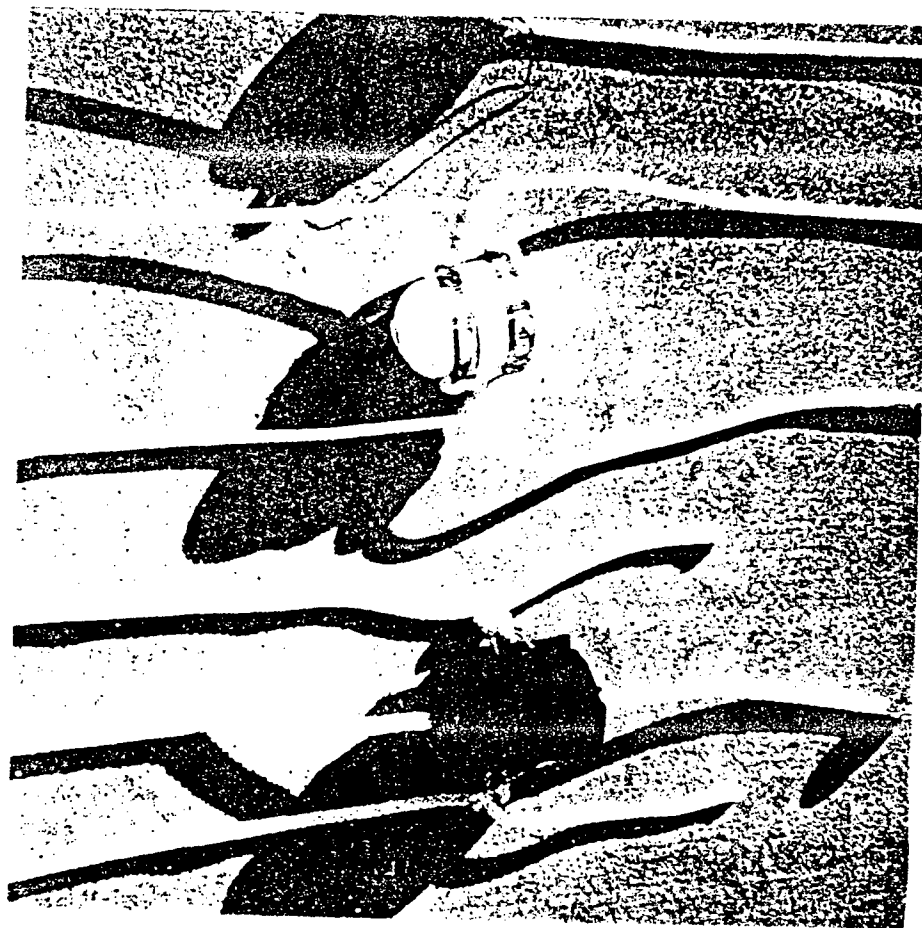
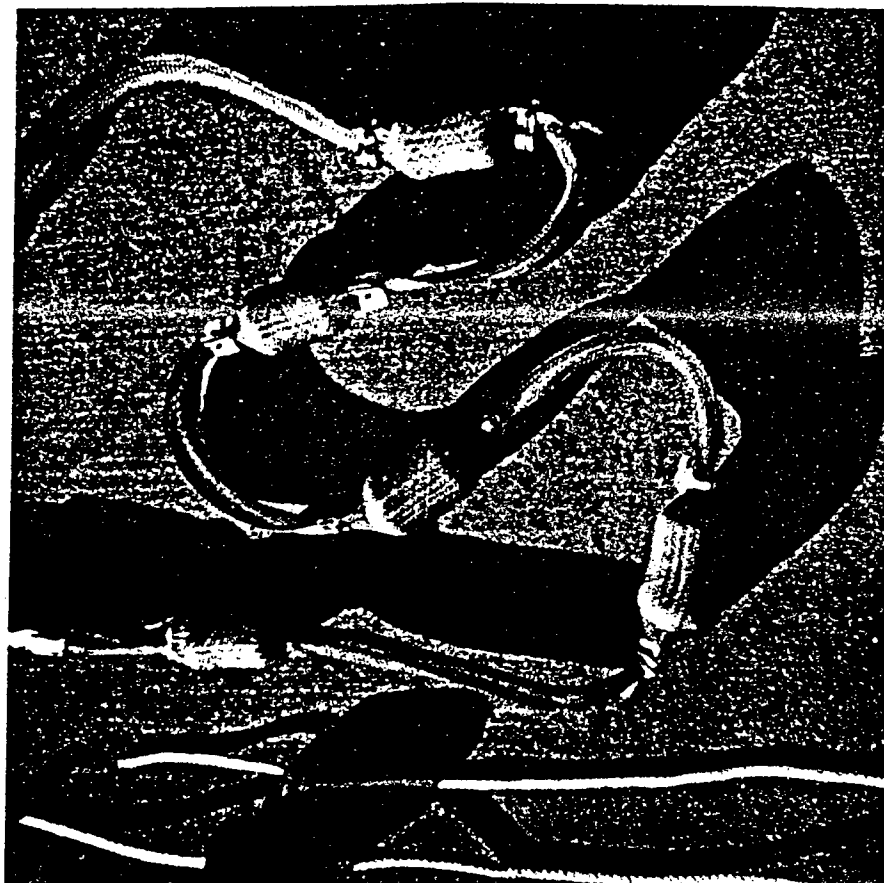


Figure 20 - Inner Core of Line Fastened to Bands





WHERE ARE WE NOW? WHAT DO WE KNOW?

- ▶ We understand, in great detail, the issues and constraints related to the APOBS grenade attachment technique.
- ▶ We understand the manufacturing and cost issues.
- ▶ We understand how product improvements can be inserted at the proper time.
- ▶ A Phase II program can address all of these issues in a very efficient manner.
- ▶ We currently have unique resources that ensure a successful and cost effective program.

RECOMMENDED PHASE II PROGRAM

- ▶ Fabricate at least two complete inert line charges and dynamically test performance.
- ▶ Use analytical and test results to select a configuration and validate performance and cost.
- ▶ Revise design to reflect modified configuration.
- ▶ Investigate relative safety issues for a modified configuration
- ▶ Investigate logistics and manprint issues.